
# Lunar Surface Operations: Part 3

## CSM Plane Change & Pre-launch - Lunar Surface

# Objectives

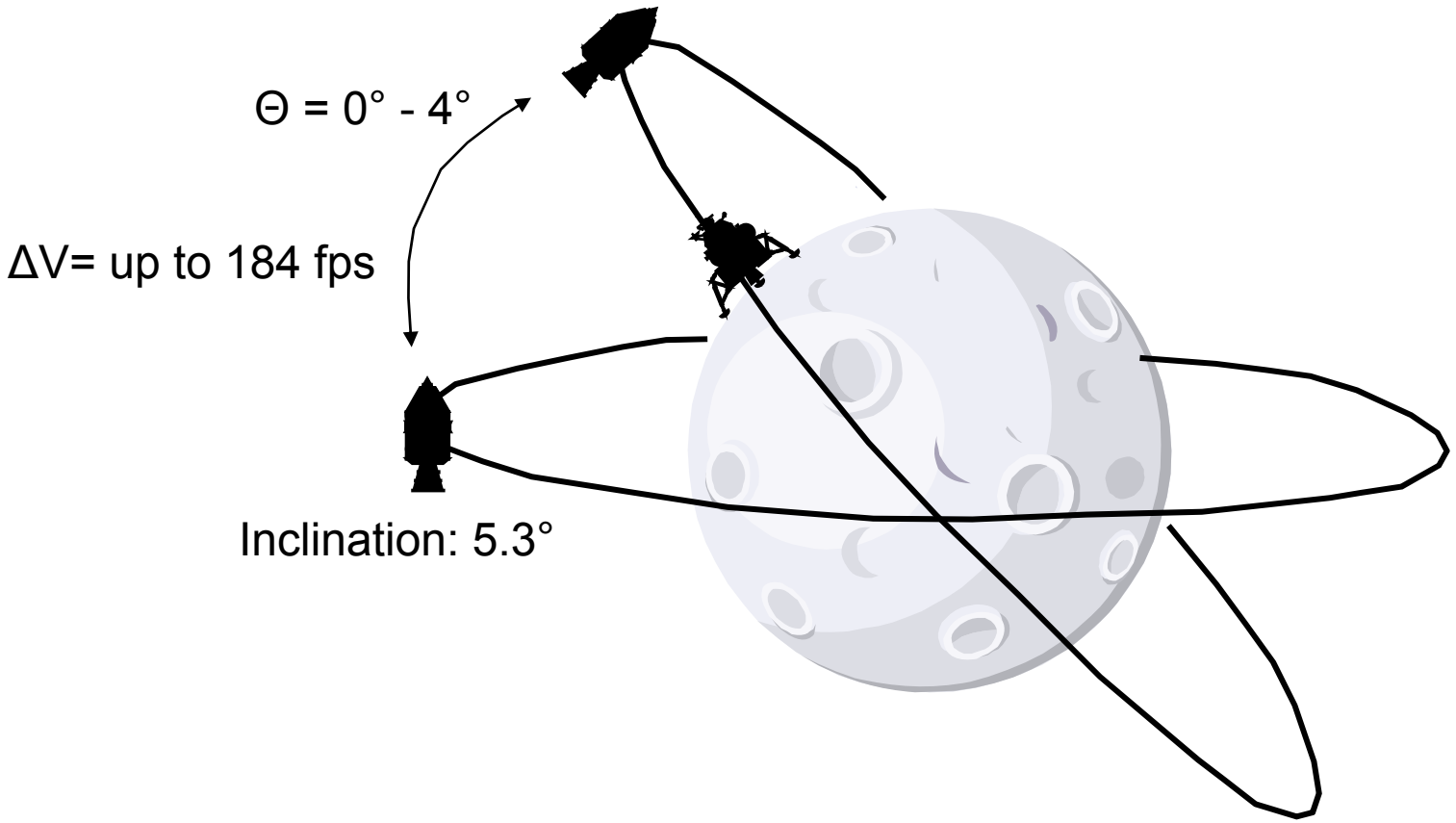
**Describe CSM plane change task**

**Describe Prelaunch phase LM activities**

**Describe Prelaunch phase CSM activities**

| Part 1 | Part 2 | Part 3 |
|---|---|---|
| Post-Touchdown Lunar Surface & Systems Checkout | Surface Duration | Pre-Launch Lunar Surface & CSM Plane Change |

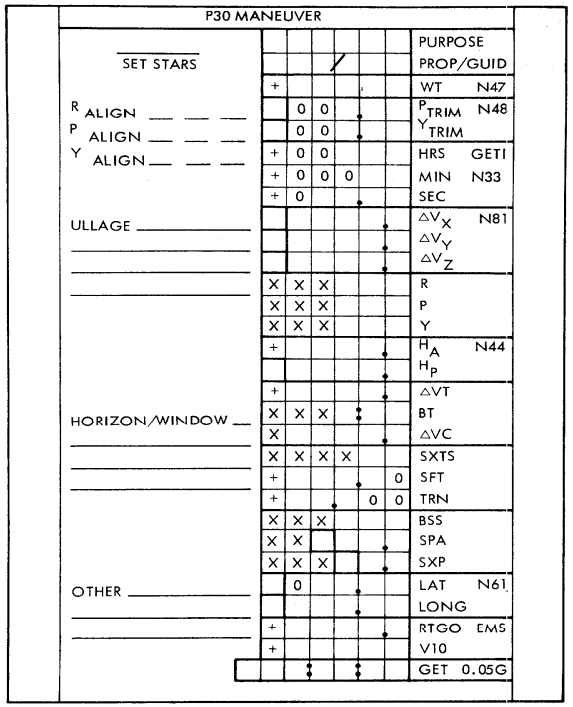
# CSM Plane Change



# CSM Plane Change (Lunar Stay Phase)

## Time (hr:min)

Touchdown + 7:30




## Command Service Module (CSM) Activity

Receive uplinked CSM state vector and REFSMMAT for plane change. Also receive P30 (External Delta V Program) data and maneuver PAD update.

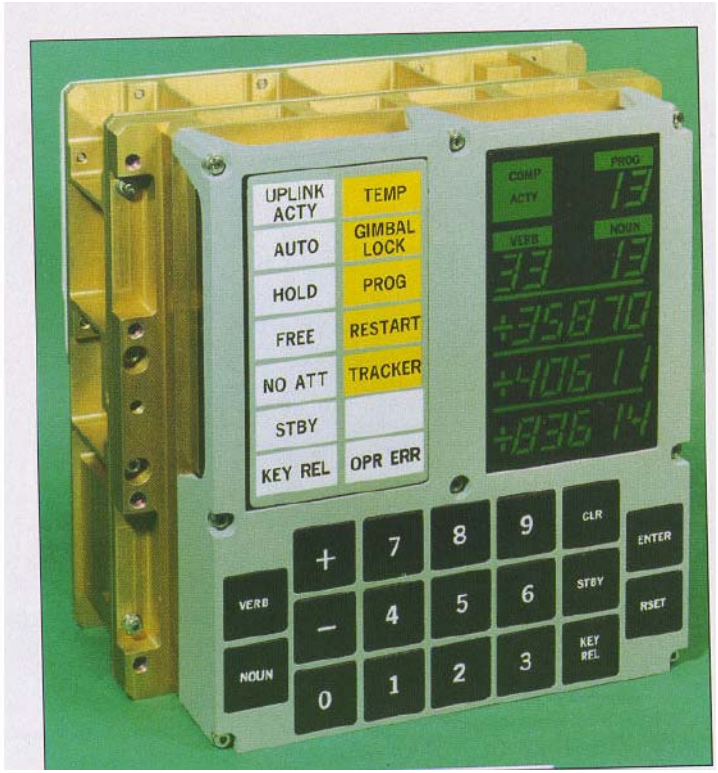
Select P52 (Inertial Measurement Unit (IMU) Realignment Program) – IMU align to preferred REFSMMAT

Perform plane change burn (if Guidance, Navigation, & Control System (GNCS) fails, perform plane change with CSM stabilization and control system (SCS) on a later revolution)

Receive lift-off REFSMMAT and pulse torque to liftoff REFSMMAT

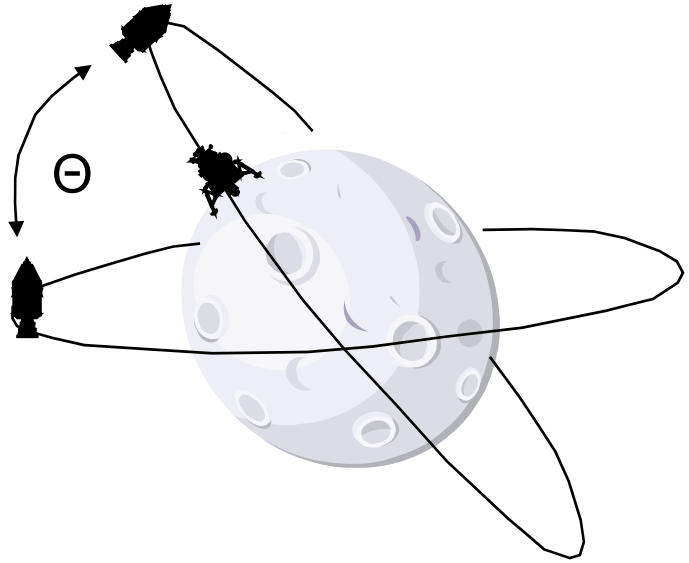
# CSM Plane Change (Lunar Stay Phase)

| Time (hr:min) | CSM Activity |
| --- | --- |
| Touchdown + 7:30 | Receive uplinked CSM state vector and REFSMMAT for plane change. Also receive P30 (External Delta V Program) data and maneuver PAD update. |
| + 8:00 | Select P52 (Inertial Measurement Unit (IMU) Realignment Program) – IMU align to preferred REFSMMAT |
| | Perform plane change burn (if Guidance, Navigation, & Control System (GNCS) fails, perform plane change with CSM stabilization and control system (SCS) on a later revolution) |
| | Receive lift-off REFSMMAT and pulse torque to liftoff REFSMMAT |



# CSM Plane Change (Lunar Stay Phase)

| Time (hr:min) | CSM Activity |
| --- | --- |
| Touchdown + 7:30 | Receive uplinked CSM state vector and REFSMMAT for plane change. Also receive P30 (External Delta V Program) data and maneuver PAD update. |
| + 8:00 | Select P52 (Inertial Measurement Unit (IMU) Realignment Program) – IMU align to preferred REFSMMAT |
| + 9:20 | Perform plane change burn (if Guidance, Navigation, & Control System (GNCS) fails, perform plane change with CSM stabilization and control system (SCS) on a later revolution) |
| | Receive lift-off REFSMMAT and pulse torque to liftoff REFSMMAT |



# CSM Plane Change (Lunar Stay Phase)

| Time (hr:min) |  CSM Activity |
|---|---|
| Touchdown + 7:30 | Receive uplinked CSM state vector and REFSMMAT for plane change. Also receive P30 (External Delta V Program) data and maneuver PAD update. |
| + 8:00 | Select P52 (Inertial Measurement Unit (IMU) Realignment Program) – IMU align to preferred REFSMMAT |
| + 9:20 | Perform plane change burn (**if Guidance, Navigation, & Control System (GNCS) fails**, perform plane change with CSM stabilization and control system (SCS) on a later revolution) |
| | Receive lift-off REFSMMAT and pulse torque to liftoff REFSMMAT |

Verified CSM was maneuvered to proper burn attitude by using sextant and star per PAD. Trunnion angle within 1° of PAD value, else delay burn.

Monitor attitude to determine if CSM drifting.

# CSM Plane Change (Lunar Stay Phase)

| Time (hr:min) |  CSM Activity |
|---|---|
| Touchdown + 7:30 | Receive uplinked CSM state vector and REFSMMAT for plane change. Also receive P30 (External Delta V Program) data and maneuver PAD update. |
| + 8:00 | Select P52 (Inertial Measurement Unit (IMU) Realignment Program) – IMU align to preferred REFSMMAT |
| + 9:20 | Perform plane change burn (if Guidance, Navigation, & Control System (GNCS) fails, perform plane change with CSM stabilization and control system (SCS) on a later revolution) |
| + 10:00 | Receive lift-off REFSMMAT and perform IMU alignment to liftoff REFSMMAT |

# Alignments, Alignments, Alignments

- Essentially, these tasks were performed to provide the most accurate LM position on the moon for guidance and insure that all guidance systems had the most accurate state vector data, and IMU alignment, both of which were essential for ascent.

- IMU were highly susceptible to drift, so alignments were done repeatedly.

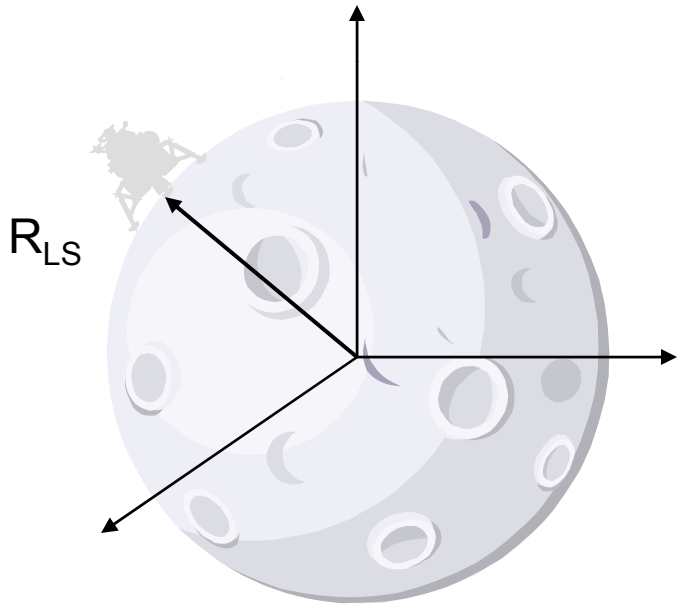
# Prelaunch Phase

| Time (hr:min) | Lunar Module (LM) Activity |
| --- | --- |
| Lift-off – 2:55 | Power up the Abort Guidance System (AGS) and Primary Guidance, Navigation, & Control System (PGNCS) |
| | Receive uplinked Command Service Module (CSM) state vector (LO) and LM position vector on the lunar surface RLS |
| | Perform Rendezvous Radar (RR) self test |
| -2:30 | Select P57 (LM Guidance Computer Surface Alignment program), Alignment Technique 3 (AT3) - Align Inertial Measurement Unit (IMU) to landing site REFSMMAT (T(align = Time of Ignition (TIG) |
| | Align AGS to PGNCS after completion of P57 |
| | Perform AGS gyro calibration |
| | Align AGS to PGNCS |
| | Store AGS azimuth and read data to ground |

# Prelaunch Phase

## Time (hr:min)

Lift-off – 2:55




## LM Activity

Power up the Abort Guidance System (AGS) and Primary Guidance, Navigation, & Control System (PGNCS)

Receive uplinked Command Service Module (CSM) state vector (LO) and LM position vector on the lunar surface $R_{LS}$

Perform Rendezvous Radar (RR) self test

Select P57 (LM Guidance Computer Surface Alignment program), Alignment Technique 3 (AT3) - Align Inertial Measurement Unit (IMU) to landing site REFSMMAT (T(align = Time of Ignition (TIG)

Align AGS to PGNCS after completion of P57

Perform AGS gyro calibration

Align AGS to PGNCS

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# Prelaunch Phase

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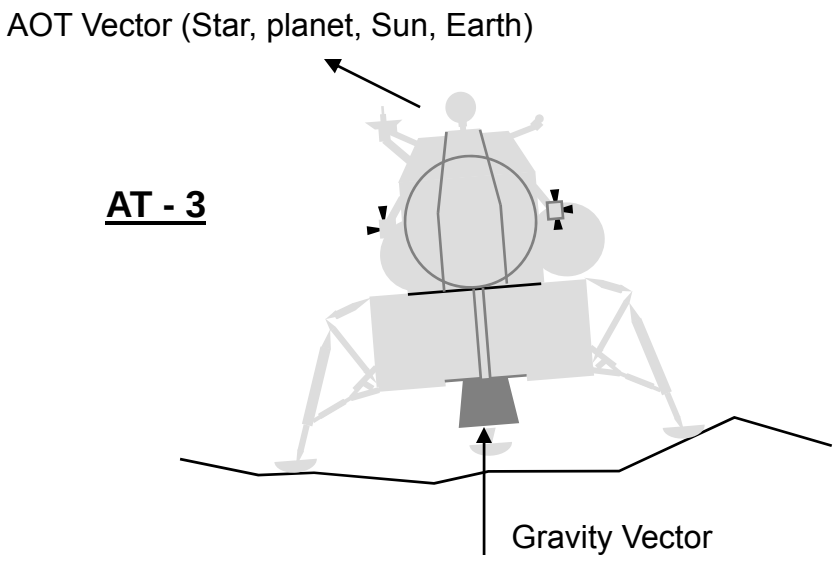
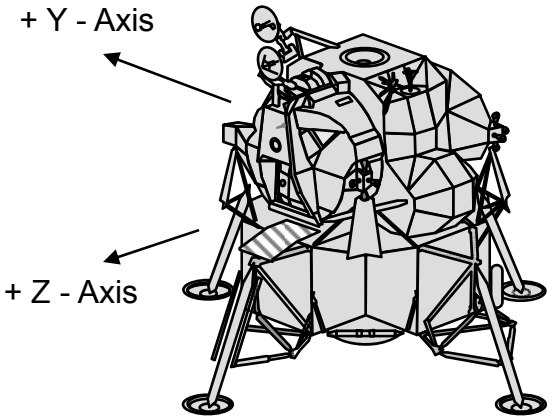
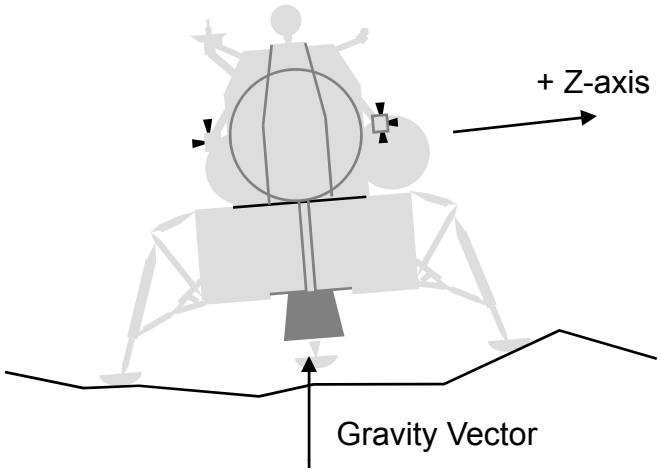


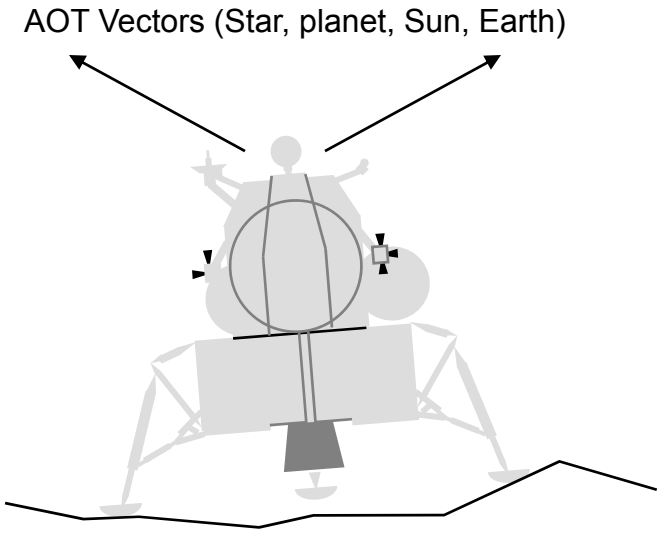
# Alignment Options



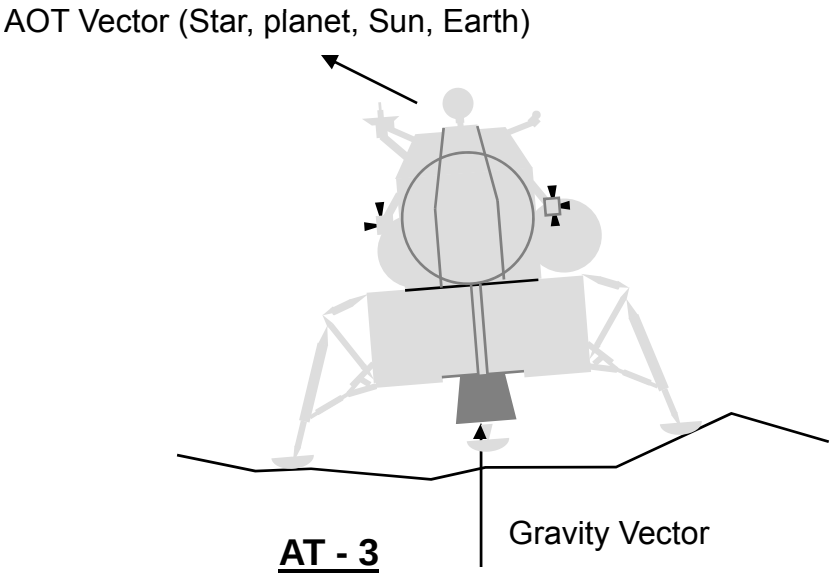

**AT - 0**




**AT - 1**




**AT - 2**




**AT - 3**

# Prelaunch Phase

| Time (hr:min) | LM Activity |
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| Lift-off – 2:55 | Power up the Abort Guidance System (AGS) and Primary Guidance, Navigation, & Control System (PGNCS) |
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| | Perform Rendezvous Radar (RR) self test |
| -2:30 | Select P57 (LM Guidance Computer Surface Alignment program), Alignment Technique 3 (AT3) - Align Inertial Measurement Unit (IMU) to landing site REFSMMAT (T(align = Time of Ignition (TIG) |
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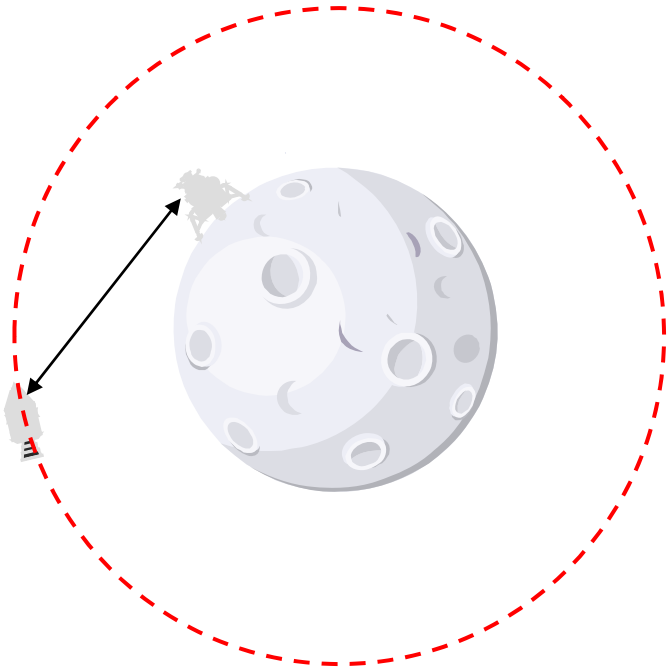
# Prelaunch Phase

## Time (hr:min)

Lift-off – 2:05



## LM Activity

Select P22 (Lunar Surface Navigation program) – track Command Service Module (CSM) in no update mode

Rendezvous Radar (RR) - OFF

Initialize Abort Electronics Assembly (AEA) time bias and perform Coupling Data Unit (CDU) zero with Abort Guidance System (AGS) state vector update

Receive ascent PAD and load values

Verify AGS ascent parameters

Select P57 (LM Guidance Computer Lunar Surface Alignment program) Alignment Technique 3 (AT-3) – align Inertial Measurement Unit (IMU) to t(align) REFSMMAT at time of ignition (TIG)

Align AGS to Primary Guidance, Navigation, & Control System (PGNCS)

# Prelaunch Phase

| Time (hr:min) | LM Activity |
| --- | --- |
| Lift-off – 2:05 | Select P22 (Lunar Surface Navigation program) – track Command Service Module (CSM) in no update mode |
| | Rendezvous Radar (RR) - OFF |
| | Initialize Abort Electronics Assembly (AEA) time bias and perform Coupling Data Unit (CDU) zero with Abort Guidance System (AGS) state vector update |
| -1:30 | Receive ascent PAD and load values |
| | Verify AGS ascent parameters |
| -0:45 | Select P57 (LM Guidance Computer Lunar Surface Alignment program) Alignment Technique 3 (AT-3) – align Inertial Measurement Unit (IMU) to t(align) REFSMMAT at time of ignition (TIG) |
| | Align AGS to Primary Guidance, Navigation, & Control System (PGNCS) |

# Prelaunch Phase

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| Lift-off – 2:05 | Select P22 (Lunar Surface Navigation program) – track Command Service Module (CSM) in no update mode |
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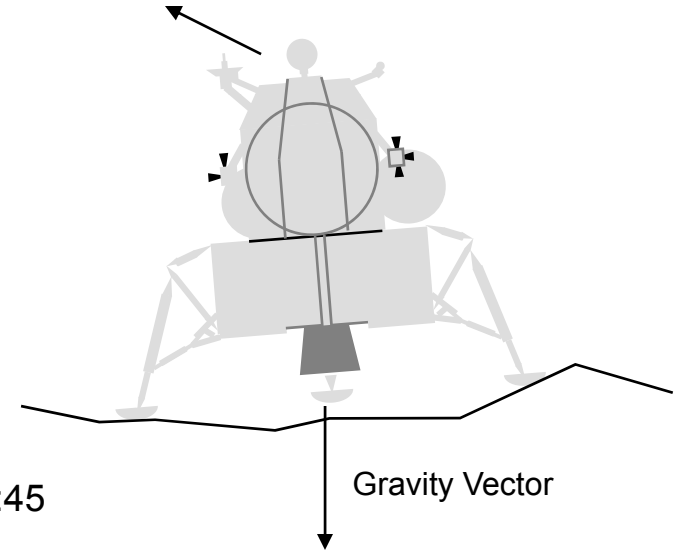
# Prelaunch Phase

## Time (hr:min)

Lift-off – 2:05

AOT Vector (Star, planet, Sun, Earth)




-0:45

## LM Activity

Select P22 (Lunar Surface Navigation program) – track Command Service Module (CSM) in no update mode

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# Prelaunch Phase

| Time (hr:min) |  LM Activity |
|---|---|
| Lift-off – 0:45 | Store updated Abort Guidance System (AGS) azimuth |
| | Read AGS azimuth to Mission Control Center (MCC) - Houston |
| | Receive LM Guidance Computer (LGC) gyro compensation (if necessary) |
| -0:30 | Enter AGS lunar align |
| | Select P12 (Ascent Program) – load Primary Guidance, Navigation, & Control System (PGNCS) ascent targeting parameters |
| -0:10 | Initialize AGS state vectors from PGNCS downlink |
| -0:02 | Exit lunar align and enter AGS guidance steering |
| - 10 sec | Arm ascent engine and press Abort Stage button to enable LGC redundant engine on circuitry and staging. |

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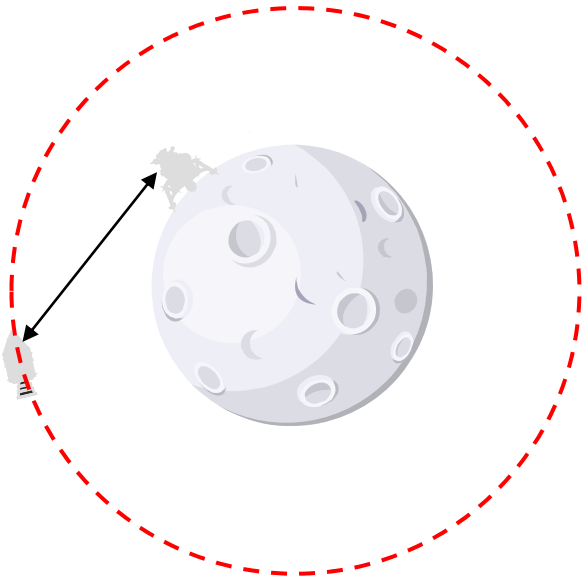
| - 10 sec | Arm ascent engine and press [Abort Stage] button to enable LGC redundant engine on circuitry and staging. |

# Prelaunch Phase

| Time (hr:min) | CSM Activity |
| --- | --- |
| Lift-off – 3:40 | Select P52 (Inertial Measurement Unit (IMU) Realignment program) – align to REFSMMAT uplinked after plane change |
| -2:05 | Select P22 (Landmark Tracking program) – Sextant tracking of landmark |
| -1:40 | Receive P27 (Command Module Computer (CMC) Lunar Module (LM) Guidance Computer (LGC)) update – lunar surface flag reset, CSM state vector at lift-off, and nominal LM insertion vector (time tagged at insertion + 18 minutes) |
| -1:30 | Select P52 program – IMU realign to REFSMMAT |
| -0:20 | Maneuver to preliminary tracking attitude |
| -0:10 | Select P22 program and ORB RATE attitude control in preparation for sextant tracking of LM |

# Prelaunch Phase

| Time (hr:min) | CSM Activity |
| --- | --- |
| Lift-off – 3:40 | Select P52 (Inertial Measurement Unit (IMU) Realignment program) – align to REFSMMAT uplinked after plane change |
| -2:05 | Select P22 (Landmark Tracking program) – Sextant tracking of landmark |
| | Receive P27 (Command Module Computer (CMC) Lunar Module (LM) Guidance Computer (LGC)) update – lunar surface flag reset, CSM state vector at lift-off, and nominal LM insertion vector (time tagged at insertion + 18 minutes) |
| | Select P52 program – IMU realign to REFSMMAT |
| | Maneuver to preliminary tracking attitude |
| | Select P22 program and ORB RATE attitude control in preparation for sextant tracking of LM |



# Prelaunch Phase

| Time (hr:min) | CSM Activity |
| --- | --- |
| Lift-off – 3:40 | Select P52 (Inertial Measurement Unit (IMU) Realignment program) – align to REFSMMAT uplinked after plane change |
| -2:05 | Select P22 (Landmark Tracking program) – Sextant tracking of landmark |
| -1:40 | Receive P27 (Command Module Computer (CMC) Lunar Module (LM) Guidance Computer (LGC) update) – lunar surface flag reset, CSM state vector at lift-off, and nominal LM insertion vector (time tagged at insertion + 18 minutes) |
| -1:30 | Select P52 program – IMU realign to REFSMMAT |
| -0:20 | Maneuver to preliminary tracking attitude |
| -0:10 | Select P22 program and ORB RATE attitude control in preparation for sextant tracking of LM |

# Prelaunch Phase

| Time (hr:min) |  CSM Activity |
|---|---|
| Lift-off – 3:40 | Select P52 (Inertial Measurement Unit (IMU) Realignment program) – align to REFSMMAT uplinked after plane change |
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# Prelaunch Phase

| Time (hr:min) |  CSM Activity |
|---|---|
| Lift-off – 3:40 | Select P52 (Inertial Measurement Unit (IMU) Realignment program) – align to REFSMMAT uplinked after plane change |
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# Prelaunch Phase

| Time (hr:min) |  CSM Activity |
|---|---|
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| -1:40 | Receive P27 (Command Module Computer (CMC) Lunar Module (LM) Guidance Computer (LGC)) update – lunar surface flag reset, CSM state vector at lift-off, and nominal LM insertion vector (time tagged at insertion + 18 minutes) |
| -1:30 | Select P52 program – IMU realign to REFSMMAT |
| -0:20 | Maneuver to preliminary tracking attitude |
| -0:10 | Select P22 program and [ORB RATE] attitude control in preparation for sextant tracking of LM |

# Summary

**Described CSM plane change task**

**Described Prelaunch phase LM activities**

**Described Prelaunch phase CSM activities**

# References

Apollo Mission Techniques, Mission H-2 and Subsequent, Lunar Surface Phase; Final Issue; January 30, 1970